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TWO SWEDISH OBSERVATORIES

Above—View of the Lund Observatory. *Below*—The new Stockholm Observatory, with Straits of the Baltic Sea in the background.

Journal of the Royal Astronomical Society of Canada, 1931.

THE UPSALA OBSERVATORY

Above—The main building. *Below*—The observatory in the winter. The smaller buildings contain two astrographic telescopes.

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GLIMPSES OF SWEDEN—ITS LIFE AND SCIENCE*

By HARALD PETERSSON

(With plates XVII, XVIII)

FOREIGNERS, who arrive at Stockholm, the capital of Sweden, are sometimes surprised that there are no bears strolling in the streets among the Swedish people, and they are possibly somewhat disappointed not to find them there. They had thought that the climate and other conditions, for instance the civilization, should be more convenient for bears than for human beings.

There is also often some uncertainty about what Sweden really is and where in the universe it is located. That Sweden happens to be confused with Switzerland is not so remarkable because of the resemblance of the names of the countries, but when a person thinks that Sweden is a spot in Copenhagen, Denmark, even a spot of a very tolerable extension, or that Oslo, the capital of Norway, is located in Stockholm, then we Swedes feel sorry. We used to distinguish between the three countries, Sweden, Norway, and Denmark. We are quite sure that we are different nations, which have different capitals and which are not suburbs to each other. And we like to hear that foreigners know that. Of course, we do not mind if they call us Scandinavians—it would correspond to the case of a foreigner calling a Canadian an American—but we are like other nations, proud of our country, and we are glad if and when things concerning us are called by their right names.

*Seminar address, D.A.O., Victoria, B.C., April 17, 1931.
Dr. Petersson, of Upsala, Sweden, spent some weeks at the D.A.O.—Ed.

If you don't mind, I will start this talk by giving you some glimpses from Swedish life and Swedish conditions before I proceed to the astronomical works dealt with in Sweden.

To begin with we may state that Sweden is as far advanced as any other civilized country of the world, and in some respects it is among the leading nations. For instance, we have no illiterates—every Swede can write and read his language. There is no other European country which can show such a good state of things.

Sweden is located in the Scandinavian peninsula and is separated from Norway by a vast ridge of mountains. It runs north and south through more than 13½° latitude and it occupies an area three times that of England. About 15 per cent. of the land is within the Arctic Circle, and there it is of course pretty cold, but not so cold as in corresponding parts of Russia, Asia and America, due to the warm water drifts in the Atlantic Ocean. In the middle and southern parts of Sweden the climate is very good. For February, which is the coldest month, Stockholm has a mean temperature of 25.7° Fahrenheit. For the warmest summer month—July—Stockholm has the mean 62° Fahrenheit.

The length of the Swedish summer day varies between wide limits. In the most northern parts of Sweden, at about 68° latitude, the sun is continuously above the horizon during two months. It is curious to see the sun descend in a wide circle and reach its lowest position at midnight but still not disappear. When we advance more towards the south, the sun is not above the horizon all the night, but on account of the sun's orbit being not very much inclined against the horizon, the sun will never be very far under the horizon and consequently the twilight lasts for a long time. In fact daylight will, for this reason, last throughout the whole night for vast regions of the country, where the sun is not continuously above the horizon.

The bright nights are a striking feature of our summer which never fails to surprise the stranger. He will be somewhat confused on account of the continuous day lasting for weeks or months and it will seem curious to him to talk about night and take a rest for night when the sunbeams are looking through his window. Even

at the latitude of Upsala, near the 60°, the nights around the summer solstice are so bright that one can without difficulty read a newspaper at any hour of the night. The bright nights prevent Swedish astronomers from observing in summer time. From about April 15th until August 15th we can hardly do any observational work at Upsala. We must rest on our laurels and plates gained in winter time. This is a fault by nature, seen from an astronomical standpoint, which will be hard to correct. At the observatory of Lund the conditions are more convenient as it is located so far to the south—55° latitude.

The population of Sweden is about 6,000,000. It should be much larger if so many people had not emigrated, especially to the U.S.A. Emigration began about 200 or 300 years ago when Swedes founded the colony New Sweden in the present State of Delaware. Since then it has been going on almost continuously so that now about 2,000,000 Swedes or descendants of Swedes live in U.S.A. One of the most well-known is Charles Lindbergh.

The Swedes have since early days had an inclination to travelling and the old vikings of Sweden made voyages to remote countries, for instance the present England and France. The inhabitants of Normandy, France, are descendants of these vikings or northmen, as they were called, and from the names of places in England we can find that they have also taken part in ancient English history. But the journeys of the vikings were directed more towards the east than to the west. Thus the Swedish viking Rurik once founded the Russian Empire, a creation of which we have had but little pleasure as Sweden and Russia, with only short interruptions, have been at war with each other. But the Swedish commercial men in ancient times went farther than Russia and we have found tens of thousands of Roman, Arabic, and Osman coins in the Swedish earth, especially in the island of Gotland in the Baltic Sea. Consequently, it is obvious that a very comprehensive commerce has taken place with these foreign countries. The routes which these men of an ancient time chose were along the rivers of Russia and, in fact, it is still possible to trace their routes in the names of places which are often of Swedish origin.

Since ancient times Finland belonged to Sweden, and through successful wars, especially during the 17th century when Gustavus Adolphus the Second was King of Sweden its area increased most considerably so that it at that time constituted one of the most powerful kingdoms of Europe. It then consisted of Sweden, Finland, the present Estonia, Latvia, Lithuania and the northern part of Germany. During the 18th and 19th century we lost everything located out of the borders of the Scandinavian peninsula, but obtained Norway as a compensation. But it was an awful compensation for the Norwegians liked liberty more than Sweden and consequently caused us much trouble. The result was that Norway, in 1905, was allowed to separate from Sweden. It was effected without any war.

During the last century Sweden has not been such an important political factor as earlier. It has turned its interest to peaceful works and is now developing to a financial and industrial power of importance, comparable with most of the great powers of Europe. I will in a few words mention the Swedish industries whose products are known over great parts of the world.

First there is the match industry, which has been merged into one single Trust. This organization now covers the whole world and controls the production of matches in most countries. It is the genius of Mr. Krueger, a Swedish engineer, which has performed this development. Further, there is production on a large scale of wood pulp, which is used for making paper. Of all wood pulp produced by the world more than one-third comes from Sweden. Timber is exported, principally to England, but during the last two years the exportation has decreased on account of the dumping by Soviet Russia. Of no less importance are the iron industries. Sweden's iron deposits are amongst the richest in the world. Of Europe's total resources in high percentage iron-ore more than 90 per cent. is to be found in mines in northern Sweden. In the 18th century Sweden took first place among iron-producing countries. The use of coal later changed this pre-eminence. As regards quality, however, Swedish output is unsurpassed. The purest iron used in special quality machinery comes from Sweden.

The waterfalls of Sweden produce an enormous amount of electric energy and in fact the electric industries are among our most important ones. Swedish motors and generators are sent over great parts of the world. A rather new world article is the Electro Lux-refrigerator, which seems to be better than other kinds of refrigerators. The automatic Aga-light which is now in use in light-houses all over the world is a Swedish invention. By this excellent invention the light-house will automatically be shining after sunset and be extinguished after sunrise. It is possible to leave the light-house without any supervision for a whole year. It depends upon the different changes in length of different metals when they are exposed to changes in temperature.

A world's industry is further the Swedish ball-bearings, S.K.F., which reduce immensely the friction in machinery of different kinds.

The number of telephones in Sweden amounts to 440,000, that is 1 to 14 inhabitants. The corresponding figures in Great Britain are 1 to 40. Stockholm has a larger number of telephones in proportion to its population than any other town of the world. Swedish firms have been employed in setting up and managing central telephone establishments in several other countries in Europe as well as in America. Sweden possesses a highly developed network of railways, the total length of the lines amounting to about 10,000 English miles. In proportion to the population, this is the highest figure reached by any European country.

Finally, I will only mention the invention of precision measures carried out by a Swedish engineer, which enables a factory to produce articles of exactly the same size. Henry Ford understood the importance of the invention and appointed the inventor to his firm. Now every factory which produces standard articles considers it necessary to use these precision measures. It is, in fact, this invention which makes it possible, for instance, to get minor motor car articles everywhere which fit exactly in any car of a given trade-mark.

Education is on a high standard. In our high schools every pupil must study about fifteen subjects, among them English, Ger-

man, and French. In college the same stipulation is valid. Therefore, Swedish elementary education is founded on a very broad basis. All colleges have to teach the same courses and before a student can graduate from college his knowledge in the different subjects is examined by university professors elected by the education board. In this way all students have the same minimum amount of knowledge when they enter universities. There they can arrange their studies in an arbitrary way. Nobody but the student himself, and his nearest relatives, I suppose, cares about it. There is no fixed time for a given degree. He can study three of four years for his first degree, but he can also use twice this time. A university professor has no duty or right to examine the student's knowledge before the student wishes an examination. By this system we gain more deepening of our studies but, on the other hand, it is a dangerous system for many persons as it allows a less ambitious student to lose much valuable time. Our university studies are comprehensive and it takes about ten years after the college years to get the degree Ph.D., sometimes a longer time. Before we can get this degree we have to print a doctor dissertation and defend its statements in a public discussion with a member of the faculty, and two other persons.

There are four universities in Sweden: Upsala, Lund, Stockholm, and Gothenburg. The oldest one, Upsala, was founded in 1477; Lund in 1668, Stockholm and Gothenburg date from the 19th century and have not yet got all faculties complete. Technical faculties are to be found in Stockholm and Gothenburg. Colleges with teaching on technical subjects are also found in several other cities.

More than 99 per cent. of the population belongs to the Swedish Lutheran Church, of which the king, who must profess the pure evangelic creed, is the supreme administrator. The non-Protestants number about 11,000, the Jews 6,500, and Roman Catholics 3,500. All citizens contribute to the Swedish church in consideration of the secular duties of the priests. Contributions may be reduced for those who support another church which is legally recognized. In this connection it may be noted that tax for income and property is

comparatively high in Sweden. Every person whose income exceeds about $200 a year has to pay 10 to 15 per cent. as tax. For real estate the tax is somewhat lower.

Among eminent Swedish scientists in ancient and modern times I will mention Anders Celsius, who calibrated the centigrade thermometer and besides was a very distinguished astronomer. Further Ångström, who introduced the Ångström-unit in spectroscopy. Other world-known names are Carl von Linne, the "flower king," and Berzelius, the chemist who introduced the chemical denotations now used. A scientist of recent times was Svante Arrhenius, who put forth the theory of ionization in solutions and also dealt with physics and astronomy. As known, he introduced the theory of the radiation pressure. The physicist Siegbahn, who is the leading man in X-ray researches, and the chemist Svedberg, who has dealt with colloidal solutions and has determined molecular weights of certain protein stuffs, are perhaps the two scientists who are just now most widely known. They have students from all parts of the world in their laboratories.

Among explorers I mention Nordenskjöld, who discovered the northeast-passage through which it is possible to travel from the Atlantic Ocean north of Asia to the Pacific Ocean, and S. A. Andre, who tried to go to the North Pole in a balloon. The remains of Andre's expedition were, as is known, found in 1930 after having been buried in the polar ice for 33 years. The diaries found give a very clear idea of the hardships, since the balloon had come down on the polar ice; so do the photographs taken by the expedition. It is most remarkable that it has been possible to develop these after so many years. The best known Swedish explorer just now is Sven Hedin, who at present is leading a large expedition in the interior of Asia.

Swedish physicians are considered to be very good, many of them being world-known. Here may be mentioned among others Henschen, who was the first to locate a given kind of sensation to an exactly defined portion of the human brain; Gullstrand, discoverer of the yellow spot in the eye and the man who has probably done the most in recent times to explain the optics of the eye, and F[illegible]hræus,

whose methods for discovering illness by changes in the blood are used in every modern hospital. Other eminent physicians and surgeons are Hammarsten, Hammar, Forssell, Nyström, Key, and Jacobæus.

Swedish art and literature have had many excellent exponents. Anders Zorn, painter and one of the most famous etchers who ever lived, and the sculptor Carl Milles, who has created masterpieces well-known by every art lover, being among the best known. Among architects Boberg and Tengbom may be mentioned and, of course, Östberg, who designed and built the city hall of Stockholm. This building is considered to be the most beautiful and original architectural work in modern time. It is influenced by Italian art, but is still an independent work with very Swedish features. Its beauty has to a great extent contributed to the pertinency of calling Stockholm "Venice of the North." As a general statement we may say that modern Swedish architecture is distinguished and successful. It is interesting to see that to an exhibition of architecture in U.S.A. last year only Swedish and American architects were invited.

The best known singer was Jenny Lind, the Swedish nightingale, and Kristina Nilsson de Casa Miranda. At present many of our singers are connected with the most prominent Italian, German and American operas. Swedish literature is not so much known in other countries. An exception is the work of Strindberg, whose dramatic plays are often produced, especially in Germany, and Selma Lagerlöf's fascinating stories and novels, which are translated into most languages. Her masterly "Gösta Berlings Saga" and the delightful journey of "Nils Holgersson" are known all over the world.

Among other persons who are well known in foreign countries, I mention Naton Söderblom, at present archbishop, and the man who has perhaps been the most successful in uniting Christianity in the world. In many countries, too, Emanuel Svedenborg, a mystic and founder of a religious association, is well known.

Then a few words may be said about the Swedish language. It is closely related to Danish and Norwegian. A citizen of one country can fairly well understand another from one of the two other countries. It is also, but not so closely, related to German.

Swedish is spoken, outside of Sweden, in parts of Finland and Estonia and often among the first and second generations of Swedish immigrants in U.S.A. It is characterized by a very distinct pronunciation and is said to be, together with Italian, the language which is most fitted to singing. The spelling is possibly sometimes curious, but in this respect it can hardly compete successfully with the English language. As a parenthesis it may be mentioned that the Swedish university professor, Zachrisson, who is interested in an adequate world-language, has modified the spelling of English. His simplified English, which he calls Anglic, has gained much interest in reforming circles in England as well as in America. One of many differences between English and Swedish language is that the definite article is put at the end of a substantive in Swedish. It may be understood by the following example—The English word "book" is in Swedish "bok," but "the book" is in Swedish "boken." "En" in "broken" is the so-called end-article. A curious matter of fact is too, that certain Swedish words get different meanings due to the way in which they are pronounced. For instance, the word "anden" with one accent means "the spirit," and with another "the wild duck." Swedish is taught at several universities in foreign countries.

This little account does not claim to give more than some very incomplete glimpses from a few branches of Swedish life. Many important fields of human activity have not been mentioned at all. As, for this lecture, I have had practically no other references than my memory, the cause of the incompleteness may be understood. In addition, it is true too, that an account of any subject will necessarily be influenced by the views of the person who delivers it. Certain parts of activity are by him considered more important than others. Therefore, probably there will seem to exist disproportion between different parts of this account.

As a general conclusion we may say that there has been an extended and rapid evolution in Swedish life and opinions during the 20th century. An unfortunate fact is that there are too many people of superior education in Sweden compared with the possibilities of getting positions for them. In order to get a position we

have to fulfill more comprehensive studies for a profession of any kind than is generally necessary in other countries. The fact that there is an excess of the highly educated causes many of them to emigrate to foreign countries. Thus, especially Swedish engineers, are found in many countries. They have electrified parts of the English provinces, they have put telephones in Roumania and Bolivia, they have constructed railway engines fitted for such exceptional regions as the Sahara, built railways in Turkey, electric waterpower works in India, they regulate water supplies in China, examine the occurrence of oil and ores in Canada, U.S.A., and South America, according to new principles found by Swedish inventors.

Before I proceed to the more astronomical part of this lecture I will say a few words about the Nobel prizes. They were founded in about 1890 by the Swedish engineer Alfred Nobel. He had gained a considerable fortune in the petrol-plants of Baku, Russia. He gave away his money to a Foundation which should once a year distribute 5 prizes to persons who had in an excellent way promoted progress in the world. The prizes are for physics, chemistry, medicine, literature and peace. At present they amount each one to between $40,000 and $50,000. Scientific societies all over the world could propose candidates to the Nobel Committee of Stockholm, which selects the candidates. There have been discussions sometimes about the distribution of the prizes. It has almost always concerned the prize for literature. In most recent days the presentation of the prize to Sinclair Lewis has been discussed. It is, of course, a delicate matter to choose between many good authors and to give the prize to the most eminent one. However, so much should be said that the Swedish Academy gave the prize to Sinclair Lewis to honor both him and the U.S.A. for his excellent talent of writing.

Swedish astronomy is some hundreds of years old. The first astronomer of greater importance was Anders Celsius, mentioned before. He lived in the 18th century. During the 19th century we had several eminent astronomers who usually went to the observatory of Pulkova, Russia, which at that time had a very modern equipment. They often stayed continuously and got positions as

directors or astronomers. Among these Gyldén, Backlund and Nyrén may be mentioned. One of the most distinguished astronomers near the end of the 19th and the beginning of the 20th century was Dunér. He was the first one who determined the rotation of the sun by means of the Doppler principle.

In more recent times Swedish astronomers have also gone to foreign observatories to stay. I mention Strömgren, who is director for the observatory of Copenhagen and has been president of "Astronomische Gesellschaft" for many years, and further, Strömberg, at Mount Wilson.

The first observatory founded in Sweden was that of Upsala, then came Stockholm and finally Lund. These are the only ones which are to be found in Sweden. Upsala Observatory is located close to 60° latitude and rivals with that of Helsingfors to be the most northern observatory of the world. Pulkova in Russia is located somewhat more to the south and so is Stockholm. The observatory of Lund is about 55° latitude. The principal instruments at Upsala are, one refractor and two astrographs. The visual objective of the refractor has a focal length of 540 cm. and an aperture of 36 cm. The focal length of the photographic objective is 434 cm. and the aperture is 34 cm. With this instrument most of the work which appeared from Upsala in earlier days has been done, for instance, Bergstrand's much cited determination of the parallax of 61 Cygni. In recent years it has been used by von Zeipel for studies of open clusters. His researches about the masses of the stars in Messier 37 appeared in 1921. The instrument has also been used in the last years for determinations on a larger scale of trigonometric parallaxes. The older astrograph consists of two similar triplet cameras from Zeiss-Heyde, the aperture being 15 cm. and the focal length 150 cm. With this instrument most of the work in the last 15 years has been carried out. Bergstrand and Lindblad used it for effective wave-lengths, Lundmark and Lindblad used it for determination of colours of spiral nebulae, and Lindblad has used it for his comprehensive investigations of short objective prism spectra. The newer astrograph is of about the same size as the older one. It has mostly been used for determinations of the stellar magnitudes.

The Lund instrumental resources are smaller. They have one refractor, smaller than that of Upsala, an astrograph and a meridian circle. Especially with this last instrument, valuable work concerning positions of stars in the A.G. Zone+35 to +40° has been carried out by Gyllenberg. On account of the lack of good instruments the astronomers of Lund have turned more from observational to theoretical works. To a great extent this is due to the fact that the former director, Charlier, was much interested in statistics. He has educated many very good astronomers. Among them I mention Gyllenberg, Wicksell and Malmquist. Lundmark is now director of the observatory and Gyllenberg assistant director.

It is not easy in a few words to describe Charlier's work and his influence upon astronomy in Sweden, as well as other countries. His investigations on B-stars and his methods in stellar statistics are well-known. His contributions to science during the last century have surely been of more than usual value. This fact has been noticed in many ways as through the "Festskrift," 1927, which was issued on his 65th birthday and which contains contributions by his pupils, and through the invitation some ten years ago of the University of California to give lectures in stellar statistics at that institution. These lectures appeared later in print and are a valuable source of information for everyone who treats stellar statistics.

At the observatory of Stockholm the director, Bohlin, retired some years ago and Lindblad became director. Bohlin's special interest was planetary astronomy. The instruments of Stockholm were not very good. However, during the last two or three years a new observatory has been built out of town, and it will obtain an entirely new equipment. The new observatory will obtain such valuable equipment that it will be one of the two or three biggest in Europe. The buildings are now nearly ready and it is likely one instrument has already arrived at Stockholm. The principal instruments are intended to be the following ones: a refractor with an aperture of 60 cm., a reflector with an aperture of 1 metre and an astrograph with aperture 40 cm. and focal length 2 m. With the refractor Lindblad intends to start trigonometric parallaxes and with the other two instruments spectroscopic work. I think he

intends taking up radial velocities on his programme and, of course, short objective prism spectra for a more vast and penetrating "Durchmusterung" than has been possible with the Upsala astrograph. Malmquist is observator at the Stockholm observatory and there are three other astronomers.

The staff of the Upsala observatory has been considerably reduced during the last years. Now there are only Bergstrand, director; von Zeipel, honorary professor, and three other astronomers.

Each one of the three observatories has its own series of publications. They are: Meddelanden från Lund, Meddelanden från Upsala, Meddelanden från Stockholm. Meddelanden means communications. The series from Lund is the oldest one. Upsala has had its series since about 1925 and Stockholm since about 1929. The papers issued from Upsala and Stockholm in earlier days were printed in various publications and it would sometimes be difficult to find them. Now they are collected in distinct series.

From the beginning of this century Bergstrand and von Zeipel have worked at the observatory of Upsala. Bergstrand, among other things, has studied the solar corona. In about 1910 he started investigations of the colours of stars and was actually, with Hertzsprung, the first to use the method of effective wave-lengths. From him came the proposition that standard effective wave-lengths should be measured at some observatories. By him Lindblad was introduced to the method of effective wave-lengths. Lindblad carried out at Upsala a big piece of work in this line. At that time, 1916, Lundmark also was connected with Upsala and together with Lindblad he determined, by means of the effective wave-lengths, the colours of some spiral nebulæ. As it was the first attempt ever made in this respect, it caused much interest.

Lundmark and Lindblad were at Upsala until about 1928, Lundmark continuing his work on nebulæ, which became his main interest. His doctor-dissertation gave support to Shapley's opinion that the spiral nebulæ are more remote than had been assumed previously. His investigations during the last years are, I suppose, so well known that it is of little need to mention them in detail. At present he is working on a catalogue of nebulæ. He also intends

to publish a catalogue of proper motions for spiral nebulæ. He hopes to get them from observations of nebulæ carried out in about 1875 by the late director of Upsala, Prof. Schultz, combined with observations from modern times.

So far, I have hardly mentioned von Zeipel's work. He had in his earlier days treated problems of minor planets, but about 1920 in his paper concerning Messier 37, he showed that his interest was also directed toward stellar astronomy. During the latest years he has been occupied with investigations about the interior of the stars and I think his results have been considered very good. I am sorry that I am not competent to relate more in detail his valuable investigations. They are certainly of much importance for astronomy.

As I mentioned previously, Lindblad treated effective wave-lengths. He then supposed that certain late type spectra were influenced by an absorption of some kind and hence he was led to introduce the so-called minimum effective wave-lengths. These minimum wave-lengths were found to be different, for different stars of the same spectral type, giants or dwarfs. This discovery caused him to study the supposed absorption more closely and he went to Mount Wilson in 1920, where he investigated short objective prism spectra. He really found an absorption which could account for the anomalies in the effective wave-lengths and which could also serve as a basis for luminosity determinations. In fact he found the cyanogen absorption λ 4144-4184 Ångström and λ 3883-3900 Ångström and he obtained an idea of the relation between this absorption and the absolute magnitude of a star. In later investigations on this subject he has established his method. It depends only on the cyanogen absorption and the intensity slope of the Band G. There are no line criterions, or almost none, as in other methods for determining luminosities of late-type stars. According to this method the break of the continuous spectrum at the Band G is measured by comparing the regions λ 4227-G and λ 4383-G. The degree of absorption in the cyanogen band with its first head at λ 4216 is measured by comparing the region λ 4144-4184 in the densest part of the band with the standard region λ 4227-4272. Only the cyanogen band at λ 4216 is, in fact, used as the

other one has proved to be rather inconvenient for work with the Upsala astrograph.

The spectrophotometric method used consists in the determination of the exposure-ratio for equal photographic density in two regions. For this reason a series of exposures are taken on every plate with times decreasing in the ratio $\sqrt{2}$:1. Each star thus produces a sequence of images of decreasing density. For the images of the series no widening of the spectrum is undertaken. The density in the fainter spectral region of a certain reference image, for instance the first, is compared with that of the stronger region of the following images. The point in the scale of images, for which the density in the second region equals that of the first region in the reference image, is estimated by interpolation of the tenth of an interval. The exposure-ratio characterizing the break at the band G has the character of a colour-equivalent whereas the exposure-ratios measuring the cyanogen absorption show a very strong dependence on the absolute magnitude of the stars. The measured exposure-ratios characterizing the contrast at G and the cyanogen absorption at λ 4184 are finally combined in a two-dimensional representation giving at the same time spectral type and absolute magnitude. The measured exposure-ratios for the cyanogen band regions are used primarily for distinguishing giants and dwarfs among the later types. This discrimination can mostly be made in a rough estimate without actually effecting the measurements. The spectral type of the star is determined in connection with the measurements. The classification of spectra is a modification of the Harvard system.

The method just mentioned is only available for late-type stars, G and later. For the early types Lindblad introduced a method which is based upon the intensities of the hydrogen lines. He adopted the notation λ, τ, σ, ρ, μ, κ for the varying sharpness of the lines λ denotes stars with very sharp lines; κ-stars have wide and winged lines. The method gives the absolute magnitudes with a very good accuracy.

Lindblad's methods have been used by himself and by others in Upsala. They are very convenient as they give spectra and

absolute magnitudes for a lot of stars with a minimum of observational work and measuring; especially for statistical purposes they are very valuable. They allow one person to collect much observational material in a very short time, which is scarcely possible if one is working with instruments which give more dispersed spectra. In this connection I may mention that the distance between the hydrogen lines H_γ and H_ϵ of the spectra of Upsala amounts to only 1.4 mm. The objective prism used has a refracting angle of 9°.7.

One of the investigations from Upsala based on Lindblad's methods has been carried out by me and I now wish to give some results reached ith it. The part of the sky investigated lies between declination 82° and 88° in the Carrington circumpolar zone with its centre in the celestial north pole. For about 2,000 stars I have determined spectral types and for a great part of them absolute magnitudes. The material is to be considered complete down to the apparent photographic magnitude 11.0. In certain cases stars as faint as below the 12th magnitude have been classified.

For the stars in the Carrington zone effective wave-lengths are determined at Greenwich. The Greenwich astronomers have drawn a relation between the effective wave-lengths and spectral types. As their relation was based upon a comparative scarcity of material, depending on the few known Harvard spectra, I made a new investigation of the subject. The material used was about 1,100 stars and the result was that for later type stars the curve was divided in one dwarf branch and one giant branch. The A-type stars also were divided in two branches, according to the different sharpness of the hydrogen lines. For stars between A2 and F5 the effective wave-length is constant and it is not possible by this colour equivalent to distinguish between the different spectral types within this interval. As another result we may say that if the spectral type of a star is accurately known, it is possible from the method of effective wave-lengths to decide whether it is a giant or a dwarf.

Distances and velocities of the stars in the Carrington zone have been computed by means of the photographic magnitudes and proper motions published from Greenwich. I have given the veloci-

ties in galactic co-ordinates and then the velocity ellipses for different spectral groups have been deduced. The result likely to be most interesting is the following one. Suppose we adopt the solar motion 19.5 km./sec. towards apex R.A. 270°, Dec. +30°, we find its projection on the examined region to be 16.6 km./sec. and thus the position of the centroid in galactic longitude equals 16.6 km./sec. Comparing now the speed 16.6 with the corresponding values found for different spectral groups, we find that the latter are all smaller than 16.6. The deviation is very considerable for stars of types A0-F8. It would appear difficult to state with certainty the real interpretation of the phenomenon. We should possibly think it due to errors of considerable amounts in the absolute magnitudes used for computation of the linear velocities. This explanation, however, does not hold as is evident from the closer discussion of the velocity ellipsoid. A possible interpretation of the anomaly is offered by Lindblad's theory about the rotation of the galaxy. If, from Oort's formula we deduce the effect of rotation for the component of velocity in galactic longitude for the examined region, we obtain 5.0 km./sec. Applying this value to the parallatic motion 16.6 km./sec. in galactic longitude for the present region we find that a parallactic motion of 11.6 km./sec is to be supposed. The observed parallactic motion is really 9.8 km./sec.

The difference between supposed and observed value is only 1.8 km./sec. Accordingly it is obvious that the theory of the rotation of the galaxy accounts very well for the real state of motion.

A question of greatest interest is the distribution of stars in space. I made it the subject of investigation, especially the decrease of star density with distance from the galatic plane. The region of the sky here treated lies, it is true, rather near the Milky Way (gal. lat. about 27°) and accordingly the heights of the stars over the galactic plane might be expected to be relatively small, but on the other hand we have penetrated to a comparatively great depth (about 800 parsecs) in the line of sight, therefore the heights become after all fairly considerable. Consequently we may hope to get an idea of the thinning out of the stars from the galactic plane at least for stars of types A0-A3 and giants of late types, which attain greater distances than stars of the other spectral groups.

For my investigation of the star densities I have used a method introduced by Malmquist. We accordingly assume that for an arbitrary volume of space the absolute magnitudes of the stars of a given spectral group are distributed according to a normal error curve and further that the distribution of absolute magnitudes for a given apparent magnitude may also be considered as a normal error curve. Then the numbers of stars were distributed in two tables, the first one according to apparent magnitude and absolute magnitude and the second one according to apparent magnitude and distance. From the second table the numbers of stars at different distances from the sun were obtained. Then the star density at different heights above the galactic plane was computed.

It was found that the density for the A stars decreases very rapidly as we leave the galactic plane. If the density is the unit at the height 77 parsecs, it is one-half already at about 120 parsecs. And at 300 parsecs it is quite inconsiderable. This is in close agreement with results found by Lindblad for another region. According to van Rhijn the density should not decrease so rapidly. According to him the density has not decreased to the half until at about the height 175 parsecs above the galactic plane.

For the giants of types G0-K2 the density seems to be approximately constant to a height of about 150 parsecs. If we go farther away from the galactic plane the density decreases but much slower than for the stars and reaches half of its original value at about 270 parsecs in height.

Finally, densities obtained by Lindblad from another region were combined with the densities of my region in order to see how the density lines were inclined with respect to the galactic plane. For the A stars the density lines were found to be nearly parallel to the galactic plane, for the giants of late types the lines were somewhat inclined.

The conclusions have been drawn from investigations of only two regions of the sky. To get more definite results it is, of course, necessary to examine the star density in several directions. Schalén has made a density computation from another region and combined his results with Lindblad's and mine. They seem to confirm the

assumption that the successive density-layers are parallel to the galactic plane.

By Lindblad's methods it is possible to attack many important problems in stellar astronomy and the methods allow us to reach valuable and far-reaching results in a comparatively short time. Neither do they need any comprehensive instrumental equipment. The investigations just mentioned have been carried out, as mentioned before, with the older Upsala astrograph, which is a very little instrument. With a larger one many interesting matters could be treated which with the present equipment is not possible. It is of importance that Lindblad has provided the new observatory of Stockholm with a large astrograph and we may expect that valuable results will be obtained by means of this instrument.

With these words I have finished my lecture. I hope you make allowances for a mixture of most heterogeneous matters. I should be glad if it has given you an idea of Sweden, its life and science. We Swedes like to know about foreign countries and their conditions and I have thought that you might have the same interest. I am always content when I find that I know somewhat more about matters than the Italian lady whom I once met in Florence. She asked me if the Laplanders, the nomadic people, who live in northern Sweden and who are not of the Swedish race, live at the top of the mountains, or at the base, or possibly somewhere between the base and the top.

THE FORTY-SIXTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

By H. F. Balmer

THE forty-sixth meeting of the American Astronomical Society was held at the Perkins Observatory of the Ohio Wesleyan University, Delaware, Ohio, from September 7 to 9, 1931, on the invitation of Professor Harlan True Stetson.

Austin Hall, one of the dormitories on the university campus in Delaware, served as headquarters for the society and most of those attending secured accommodation there. This kept the members together, with the result that the meetings were more enjoyable socially than would have been possible had the members been more widely scattered. Transportation to and from the observatory, four miles south of Delaware, was by electric railway and by automobile. Although concrete was being poured for the main highway in front of the observatory, thanks to Professor Stetson's efforts the observatory was kept accessible to motor traffic and no inconvenience was experienced.

At the close of the first session for papers Monday afternoon, President Edmund D. Soper of the Ohio Wesleyan University welcomed the society to Delaware and expressed his regret that it had not been possible to have the great mirror of the telescope in place for the meetings. He felt, however, that the society would agree with him that it was better not to hurry the preparation of the mirror, even for such an important occasion as this. Following this a delightful informal reception was held, refreshments being served on the observatory lawn and an excellent opportunity of inspecting the observatory equipment being provided.

The mounting of the 69-inch telescope, which will be put into service within a few months and will then be the third largest telescope in use, is of considerable interest. Similar to the 72-inch telescope at Victoria in design, the mounting was originally built to accommodate a 60-inch mirror. When the Bureau of Standards

succeeded in casting a 69-inch disc for the mirror there arose the problem of designing a larger and stronger tube for the larger mirror and, at the same time, of keeping the total weight the same as before so that the rest of the mounting could still be used. This was solved by using welded steel units, the strength of which could be calculated in advance, in place of the heavy castings ordinarily used. As a result of the adoption of this type of construction, increased size and strength were achieved with no increase in weight. The impression gained is that this will be a very efficient telescope and one with which it would be a pleasure to work.

On Tuesday afternoon, September 8, the society temporarily abandoned astronomy in favour of archaeology and made a trip to inspect the ancient mounds at Newark, Ohio, about thirty miles from Delaware. Through the courtesy of the Newark Police Department, the motor caravan of the Society was met by two members of the motorcycle squad at Granville, six miles from Newark, and escorted through Newark and back again to Granville. Previous to meeting the police escort, the caravan had become rather scattered due to the different rates of speed preferred by the various drivers. This condition was not noticed after the escort was met.

The first mounds visited were at the Mound Builders Country Club. Here a circular mound containing some twenty acres is connected by parallel mounds to an octagonal one enclosing about fifty acres. Each angle of the octagon is open with a small "sentinel mound" covering each entrance. As each of these walls is perhaps ten feet high and ten feet broad at the top a tremendous amount of labour must have been involved in their construction. The second mound visited was at the fair grounds. Here the mound consisted of a circular wall enclosing some thirty acres, in the centre of which is the so-called "Eagle Mound." This mound suggests by its shape a flying eagle and has a height of six feet and a length and breadth each of over two hundred feet. These mounds are evidence of a race which, in prehistoric times, inhabited this region and which, judging by the regular geometrical forms of the earthworks and the amount of labour necessary in their construction, must have developed a civilization of a fairly high order.

The Society banquet was held at the Granville Inn following the

visit to the mounds. Secretary R. S. Dugan, apparently unwearied by the responsibility of representing some half dozen absent officers, presided, and speeches by O. J. Lee, F. C. Jordon, D. B. McLaughlin, C. H. Smiley, H. T. Stetson, Weld Arnold, Mrs. Gingrich and H. R. Morgan added to the interest of the occasion. Later in the evening dancing was enjoyed by a number of the members.

Sessions for papers were held at the Perkins Observatory on Monday afternoon, Tuesday morning and Wednesday morning and afternoon, the extra session Wednesday afternoon being necessary to take care of a number of papers not on the original program. Twenty-seven papers were listed, five being added to the original list. In addition to these, Miss Bennett, of the Adler planetarium, gave a demonstration of two pieces of apparatus which have been developed there. One of these produced a "meteor shower" on the screen while the other gave a realistic demonstration of a total eclipse of the sun. How effective this was may be judged from the fact that a decided stillness was noticed in the room as "totality" approached!

The following is the program of papers :

1. O. J. Lee, Holger Thiele and N. L. Pierce : The Dearborn Observatory observations of Eros 1930-31.
2. C. L. Stearns : The reduction of Eros photographs taken with a visual refractor.
3. C. J. Krieger : Minor planet Aeneas.
4. N. T. Bobrovnikoff : The origin of minor planets.
5. H. T. Stetson : The 69-inch telescope of the Perkins Observatory.
6. J. A. Larrivee : On the distribution of spot centres in heliocentric latitude.
7. H. R. Morgan and Jesse Pawling : Irregularities in moon's limbs from transit circle observations.
8. R. N. Van Arnam : The spectroscopic binary 31 Corvi.
9. Otto Struve : A test of Milne's null-effect for spectral line intensities.
10. D. B. McLaughlin : Characteristics of class Be spectrum variables.
11. C. T. Elvey : Photoelectric colors of early type stars.
12. Otto Struve and H. F. Schwede : Intensities of Balmer emission lines in stellar spectra.
13. G. W. Moffitt : Recent determinations of stellar parallax with the 40-inch Yerkes refractor.
14. H. R. Morgan and U. S. Lyons : 5000 new proper motions.
15. Frederick Slocum : Committee report on 1932 eclipse; probability of clear sky, available locations, etc.
16. James Stokley : An eclipse model for the Franklin Institute Museum.

17. E. F. CARPENTER : Note on the absorption of radiation in space.
18. W. W. MORGAN : On the occurrence of europium in A-type stars.
19. C. J. KRIEGER : A spectrophotometric study of Y Ophiuchi.
20. M. F. JORDAN : On an apparent displacement of the meridian as a function of the lunar hour angle.
21. KNUT LUNDMARK : Report concerning the General Catalogue of Nebulae now in preparation at Lund (L.G.C.)
22. E. A. FATH : Photometric observations of Alpha Lyrae.
23. E. S. MANSON : A point relating to the motions of globular clusters.
24. ROSS GUNN : Electromagnetic effects that determine the stability and motion of stellar atmospheres.
25. G. VAN BIESBROECK : Stellar aberration and red shift.
26. M. F. JORDAN : A photometric investigation of the variability of plate errors for red and blue stars.
27. C. P. OLIVIER : The Illinois fireballs of July 25, 1929.

Buffalo Museum of Science,
Buffalo, New York.

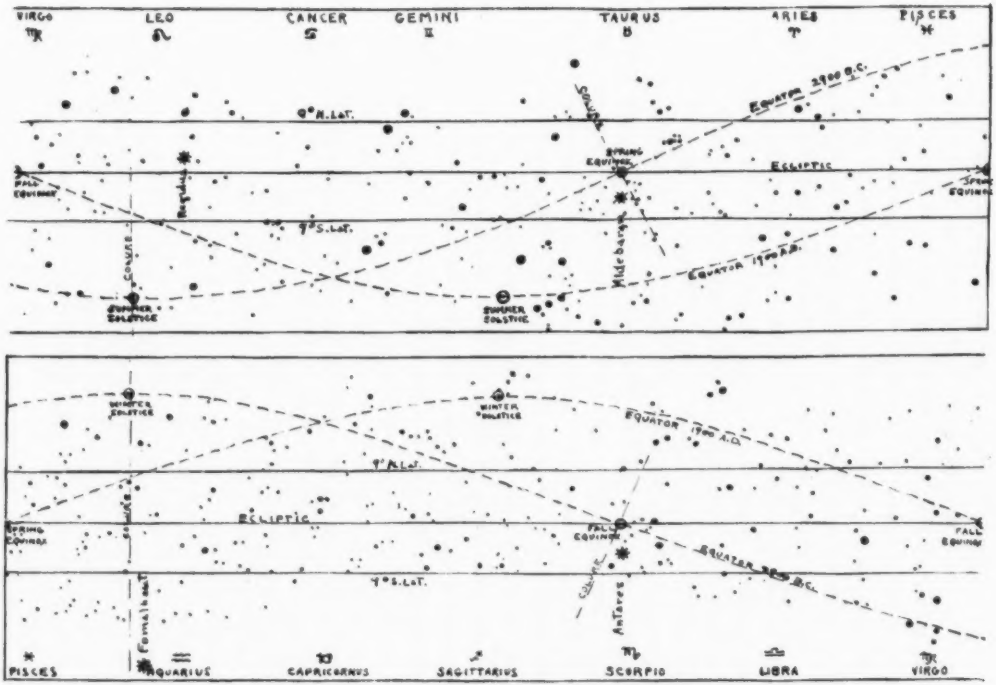
THE ZODIAC AND EARLY ASTRONOMY

By Selwyn H. Dewdney

COPERNICUS wrought a greater work than he knew. But for him our great modern astronomers might still be casting horoscopes, might still be concentrating their attention on the apparent motions of the solar system, which would have remained for them mysterious harbingers of good or of evil in human affairs. The zodiac, extending nine degrees on either side of the ecliptic in a great belt about the celestial sphere, and including all apparent paths of the sun, moon, and planets, might still have seemed to them the most significant part of the sky. Modern astronomy began when the mystery of "the wanderers" was solved.

This emphasis of ancient astronomers on the apparent solar, lunar, and planetary motions through the zodiac not only has its logical place in the development of astronomy, but also promises to provide us with an important clue as to its origin. The twelve constellations of the zodiac have come down to us from remote antiquity. Owing to the gyrating motion of the earth known as precession (see accompanying star map), which causes the equinoxes to shift westward in the sky two hours of right ascension every 2,150 years, these constellations no longer preside over the seasons from which they received their original designs and significances. Says R. A. Proctor[1]: "If we could determine the origin of these (zodiacal) figures, their exact configuration as at first devised, and the precise influence assigned to them in the old astrological systems, we should have obtained important evidence of the origin of astronomy itself." Deducing, that is, the original seasons over which the zodiacal twelve presided, and knowing those over which they now preside, a little arithmetic, with the aid of our knowledge of precession, will give us the approximate date of the beginnings of the science.

[1]R. A. Proctor—Myths and Marvels of Astronomy.



PRECESSIONAL SHIFT OF THE EQUATOR SINCE 2900 B.C.

The probabilities are that by 2900 B.C. the Babylonians had adopted a zodiac not unlike, and directly ancestral to, our own.

As yet the problem outlined by Proctor has attracted little attention. Of the few theories as to the origin of astronomy we shall consider three as throwing light on the nature of the problem and on the present state of our zodiacal knowledge. Olcott[2] deduces that the science proper was introduced into the Euphrates valley by the Akkadians about 3,000 B.C. He quotes the tradition that the zodiac has come down to us unchanged from the early Babylonians. About 3000 B.C. the four "royal" stars of the Persian calendar, Aldebaran, Regulus, Antares, and Fomalhaut (see map), occupied the four cardinal points of the sky. Early zodiacs show Mesopotamian rather than Egyptian or Indian animals, hence a Mesopotamian origin. So much for Olcott. Maunder[3], on examining a number of early planispheres, found that they showed no stars visible south of latitude 36° N., and that the position of their poles showed on the average a precession of some 4600 years since the time of their determination. This is the basis of his theory that the zodiac came into being in Northern Asia Minor about the year 2700 B.C. E. M. Plunket[4] concentrates on evidence afforded by ancient calendars. In one of the oldest of these, a Babylonian calendar described by Sayce, she finds the first three month-names translated as, "The Sacrifice of Righteousness, The Propitious Bull, and The Twins." These she finds suggestive of Aries, Taurus, and Gemini, the first three signs of the zodiac, and deduces that the Babylonian year began when the sun was in Aries. The intercalary thirteenth month, "The Dark Month of Sowing," she identifies with the mid-winter month which puts the new year at the winter solstice. The sun in Aries presided over that solstice in 6000 B.C., and Miss Plunket accordingly credits astronomy with that early date of origin in the land of Akkad.

None of these theories is convincing. Olcott's is plainly superficial. Maunder's deductions are a little too good to be true and are based on evidence which, as we shall see below, is of little value for the purpose. Later archeological research has made Miss Plunket's

[2]W. T. Olcott—Star Lore of All Ages.
[3]E. W. Maunder—Astronomy of the Bible.
[4]E. M. Plunket—Ancient Calendars and Constellations.

position untenable; we now know [5]that the Babylonian year began in the spring with the sun in Taurus.

After all it is not strange that these theories are unreliable if not altogether astray. Tradition cannot be trusted; facts are few and far between. Such evidence of early zodiacs as there is is meagre and unsatisfactory. A number of ancient planispheres and zodiacal representations has been found, it is true, but none dates further back than 1300 B.C., and such as there are present a diversity of appearance and an originality of design which goes far to refute the tradition that the zodiac has come down to us unchanged through the centuries. Let us select, as a typical example of these early zodiacs, that figured on the planisphere found in the ceiling of an Egyptian temple near Denderah[6]. The planisphere is circular in shape with a number of figures, human and animal, representing the various constellations arranged in rough spirals, their feet toward the circumference of the circle. The zodiacal twelve appear among these figures with no other distinguishing mark than their familiarity to our eyes. The ram, the bull, the lion, the scales, the scorpion, the centaur archer, the fish-goat, the waterman, and the fish are obviously present in their proper order. Virgo is doubtful, the twins extremely so; the crab is figured, but not among the zodical twelve. There is nothing to mark either equinoxes or solstices. Ursa-Major is a monster, half crocodile, half hippopotamus; the other constellations are equally foreign to our eyes. The date is uncertain but it is not older than 900 B.C. and no later than the sixth century before the Christian era. The similarity between this zodiac and our own is striking, but a difference is also there which seems to increase in the older zodiacs, for example in the oldest known specimen[7] dated 1320 B.C. and found on the banks of the Euphrates. The Babylonian calendar of a thousand years earlier seems to have lost all traces of zodiacal significance, although some have found them in the first four month names: "Nisan=Sacrifice, Aiaru=Blossom, Simanu=Fixed Time, and Du'uzu=Sounding Changes."

[5]Olmstead—History of Assyria.

[6]J. Saint-Martin—Notice Sur le Zodiaque de Denderah.

[7]A. B. Grimaldi—Catalogue of Zodiacs and Planispheres.

Since the concrete evidence is of little aid in attacking the problem, let us examine the traditional evidence preserved for us by the conservative "science" of astrology. Lilly's system[8], in vogue in 17th century England, should prove useful for our purpose. We find twelve signs: Aries the ram, Taurus the bull, Gemini the twins, Cancer the crab, Leo the lion, Virgo the Virgin, Libra the scales, Scorpio the scorpion, Sagittarius the archer, Capricornus the he-goat, Aquarius the water-carrier, and Pisces the fish. "Aries is a masculine, diurnal sign, moveable, cardinal, equinoctial; in nature fiery, hot and dry, choleric, bestial, luxurious, intemperate, and violent; the diurnal house of Mars, of the fiery triplicity, and of the east." Taurus, on the other hand, "is an earthy, cold, dry, melancholy, feminine, nocturnal, fixed, bestial sign; of the earthy triplicity, and south; the night house of Venus." Gemini is "an aerial, hot, moist, sanguine, diurnal, common, or double-bodied human sign;" Cancer is "a watery, cold, moist, phlegmatic, feminine, nocturnal, moveable sign; mute and slow of voice." Leo, "the only house of the Sun; by nature fiery, hot, dry, choleric, diurnal, commanding, bestial." Virgo: "an earthy, cold, melancholy, barren, feminine, nocturnal, southern sign; it signifies a dairy-house, corn-fields, granaries, etc.' Libra: "hot and moist, sanguine, masculine, moveable, equinoctial, cardinal, humane, diurnal." Scorpio: "a cold, watery, nocturnal, phlegmatic, northern, feminine sign;" Sagittarius is "of the fiery triplicity, in nature hot, dry, masculine, choleric; bicorporal or double body." Capricorn: "nocturnal, cold, dry, melancholy, earthy, feminine, cardinal, moveable, four-footed, southern." Aquarius: "An airy, hot, and moist sign." Pisces: "A northern, cold sign, fruitful, phlegmatic, feminine, watery; an idle, effeminate, sickly sign." Analyzing this evidence we find traces of three influences: that of the astrologer himself, which is responsible for such adjectives as "melancholy, phlegmatic, choleric, four-footed," derived from the traditional animal or person of the zodiacal sign; Graeco-Roman astrology, which first assigned Aries to Spring and to the leadership of the twelve, thereby limiting the date of its origin to the first millenium B.C.; and an older astrology,

[8]Lilly's Astrology, edited and revised by "Zadkiel."

date of its origin o the first millenium B.C., and an older astrology, almost obliterated, which appears in such expressions as "the fiery triplicity," and "of the House of Mars, and his joy." These traces of an older astrology are too vague and ill-defined for us to presume to draw conclusions from them.

The zodiacal symbols, however, show more definite signs of a remote origin. These are, in order, ♈, ♉, ♊, ♋, ♌, ♍, ♎, ♏, ♐, ♑, ♒ and ♓. ♈ is supposed to resemble a ram's head, ♉ is probably related to the Hebrew א (Aleph). ♊ is obviously the numeral two, ♋ is said to represent the crab's claws, ♌ in all likelihood is the Greek λ. ♍ and ♏ are of unknown significance, but show a mutual relation, ♎, which separates them, is a scale beam, ♐ has an obvious significance, ♑ may share with the Hebrew מ (Mêm.) a common origin, ♒ is a hieroglyph for water, and ♓ is a pair of fishes. Here we find something to go upon. The affinity between ♉ and the first letter of the Hebrew alphabet suggests that Taurus, whose sign it is, once led the zodiacal twelve. The intrusion of ♎ between ♍ and ♏ suggests that it is of later origin, a suggestion which tradition confirms. Saint-Martin[9] believes it to have been inserted by the Egyptians. Formerly its place was supplied by Scelae, the Scorpion's Claws[10]. ♑, ♒, and ♓ all have associations with water, the two latter directly, the former indirectly through the Hebrew מ which signifies water. Together with the signs should be considered the configurations of the zodiacal twelve. Aries is usually represented as a ram recumbent, Taurus as the couched head and forequarters of a bull, the Gemini as youthful twins hand in hand, Cancer as a crab, Leo as a crouching lion, Virgo as a maiden with an ear of corn (cf. its astrological significance), Libra as a pair of scales, Scorpio as a scorpion, Sagittarius as a centaur with drawn bow and arrow, Capricornus as half-goat, half-fish, the hind parts being the tail of a fish; Aquarius as a man pouring water from a jar, and Pisces as two fish attached to one another by what seems to be a pair of ropes. The last three members belonged traditionally to a great celestial sea occupying a full quarter of the heavens. Libra, the

[9]Notice sur le Zodiaque de Denderah—J. Saint-Martin.
[10]G. Costard—History of Astrology.

balance, suggests an origin at a time when it presided over the autumn equinox, about 2000 B.C. The aqueous constellations suggest connection with an extensive rainy season such as visits the Indus and Ganges valleys in the track of the monsoons.

We have until now taken it for granted that the astronomy of our fathers came from the Euphrates valley. It is necessary before proceeding to verify or to rid ourselves of our assumption. Chinese astronomy possesses no mean history. On the authority of J. B. Biot[11] we learn that as early as 2200 B.C. "un calendrier luni-solaire était depuis longtemps établi." During the second millenium before Christ an elaborate religio-regal ritual was developed, based on an astrological system. Unfortunately for our greater knowledge of Chinese astronomy the emperor Tsin-chi-hoang-ti, fearing the old order which was hostile to his regime, had a great holocaust made of all the existing works of literature and science. From the few astronomical texts which escaped we learn that the Chinese made two divisions of the zodiac, a lunar division into twenty-eight sieu, and a solar of twelve kung. These kung were gathered into four groups of three known as the Azure Dragon, the Dark Warrior, the Red Phoenix, and the White Tiger. The zodiacal twelve included such animals as the dog, the rat, the dragon and other foreign creatures. It is thus evident that we owe little if anything to the Chinese for our zodiac.

Of any relation between our zodiac and that of Aryan India we have the word of Allen[12] that "modern research finds little in Sanskrit literature to confirm this." The Hindus, who called India the land of the Crescent Moon, favoured a lunar system. The zodiac is distinctly different, Aries, for instance, being known as The Twins. Of possible significance is the association of Capricornus with Khumba the storm-god, and of Aquarius with Varuna, god of waters, but otherwise it seems that Indian astronomy may be dismissed.

We know little of the original Egyptian zodiac but enough of Egyptian astronomy to deduce that it was not the ancestor of our

[11] Precis de l'Histoire de l'Astronomie Chinois—J. B. Biot.
[12] R. H. Allen—Star Names and Their Meanings.

own. The annual flood of the Nile was the great event of the year, beginning in June, reaching its maximum in late September, and falling off from then until its recurrence. Thus the heliacal rising of Sirius which marked the turning of the flood was the great astronomical phenomenon and marked the beginning of the year. We have noted Libra as of Egyptian origin. There is a legend that Aquarius caused the overflow of the Nile by dipping his jar into its upper regions, which may point to it also as Egyptian. Otherwise there is little to suggest that our zodiac came from Egypt. The decline of the Nile civilization brought with it the innovation of an alien astronomy.

It is, then, to Assyria or to Babylonia that we may confine our attention. It is probable that both contributed to the growth of astronomy, Babylonia with its long cultural background, Assyria with its native vigour and inventive genius. More than of any other, the bull and the lion were the type-animals of the Euphratean culture. The earliest recorded name for the zodiac is Pidnush-Shame=The Furrow of Heaven, ploughed by the Bull of Light. The fourth of the twelve sons of Israel (who may have a zodiacal significance), is described by his father, "Judah is a lion's whelp,"[13] and here we have what seems more than a hint of Leo, as we have a hint of Taurus in the Hebrew Aleph. These same sons of Israel also furnish hints of Sagittarius and Capricornus if we meddle somewhat with their proper sequence. Orion was known to Babylonians as the "True Shepherd of Heaven," which confirms the leading place held by Taurus, since the two constellations are adjacent. There is much of interest that we might add concerning Euphratean astronomy but this little is practically the whole of the evidence that it had a zodiac closely related to our own. We may point the probabilities to the Euphrates valley for the birth-place of our astronomy; anything beyond that would be presumption.

Reviewing the evidence we are led to favour the opinion that the signs of our present zodiac were introduced gradually and that only a few may be traced into remote antiquity. These few suggest an origin while the vernal equinox was in Taurus, that is, between

[13]The Book of Genesis: Chap. 49, v.9.

the years 2000 B.C. and 4000 B.C., probably (see star map) about 2900 B.C.

It is interesting to conjecture how astronomy began, and from our knowledge of primitive man it is not difficult to reconstruct the story. A pastoral or agricultural race depending for its welfare on the weather would soon become familiar with the "signs and seasons" of the stars. Hesiod[14] advised the Greeks to plough at the heliacal rising of the Pleiades and to reap when they appeared in the evening sky. The diurnal progress of sun and moon through the stars would be discovered and taken advantage of to predict seasonal changes and the religious festivals with which these changes were celebrated. A luni-solar callendar would be devised and a scientific astronomy inaugurated. As the primitive culture matured into civilization a body of priests would be delegated to determine the calendar and feast days. Gradually the motions of the heavenly bodies would seem not merely to mark the seasons, but to *bring them about* by their influence. The awe-inspiring eclipses, the erratic motions of the planets, useless calendrically, would suddenly seem to have tremendous significance. Out of the infant astronomy would spring the full-grown giant astrology, and science would be swamped in superstition. It is a favourite saying with some astronomical historians that astrology mothered astronomy; it would be more truthful to describe astrology as the dangerous parasite of astronomy, for such it has proved in the past. But for Copernicus, as we have already pointed out, the truth might still be stifled by the pseudo-science.

The zodiacal problem has been as yet practically untouched, in spite of the rich and varied field of research it offers and the historical challenge it presents. Until it is dealt with adequately our knowledge of early astronomy will remain a blank; once it has been solved a great page of history will have been opened for us to read.

[14]Works and Days.

SCHWABE'S OBSERVATIONS OF SUNSPOT VARIATION*

IN the past year, 1837, the activity of the sun in producing spots was so unusually great that I was induced to look back in my diary in regard to it, where I found a very noteworthy difference in earlier years. This strengthened my determination to publish the observations which I have made for the past 12 years upon their number and size, for a similar study is unknown to me.

I believe, however, that the following remarks upon the method are necessary, for, though indeed everyone knows how to make such observations, how persistently they remain neglected.

Since 1826, when I began to observe with two Fraunhofer telescopes of 3 and 6 ft. focal lengths, I have considered as groups only those crowds of spots which remain apart and are connected by no greater or smaller spots and no cloudiness. For this reason the count of groups depends upon the power of the telescope, and it often happens that crowds of many hundreds, indeed thousands of spots become only a single number, while one only stands by itself at the same time. But the tendency of the sun to bring the spots together into an aggregation is so great that different observers in the course of a year will in fact show but slight difference in count from my numbers. Moreover, the influence which a significant difference will still have upon the result of my observations will be much diminished by a proportionate ratio, so I divide my results by the time during which I think they appeared as strongly as possible. It is not the number of groups, but their reciprocal relation which seems to me worth counting, and this forms the purpose of this communication.

The first new spot which I see at the beginning of the year, I count as No. 1, and I continue by serial numbers until the end of

*Schwabe's original account of his observations was published under the title, "Ueber die Flecken der Sonne", in *Astronomische Nachrichten*, No. 350, 1838. The accompanying translation is by Helen M. Davis for *Science News Letter*, in which it appeared April 25, 1931.—Editor.

the year, so that the old spots which continue over into the new year retain their numbers of the year before.

Of the two instruments, the 3½ ft. has an eyepiece with cross hairs for estimating the groups and a magnification of 45. With the 6 ft. I use a magnification of 64 only, to bring out every spot which must be counted in the group number, which would be overlooked in the small telescope on account of its faintness. Very seldom am I forced to use a magnification of 96 in doubtful cases. So I consider it practical to cover the objective with a capsule which for the 6 ft. has an opening of 2½ inches, and for the 3½ ft. of 1¾ inches, which can be widened by an arrangement if poor seeing in the heavens demands it. Through this I accomplish a two-fold purpose. First I avoid breaking the filters, which often causes a loss hard to replace, and second I can use brighter filters than if the objective kept its full opening. Besides, the best filters, which are unquestionably those of *Utzschneider* and *Fraunhofer*, lose in clearness and sharpness with greater saturation of colour. I employ only the yellow and greenish colours, because they give the greatest definition and the least heating. . . . .

Sunspots in Different Years

How different the numbers of sunspots and the size of the groups is at different times, the following résumé and the remarks accompanying it show:

1826	I counted 118 groups	1832	I counted 84 groups
1827	I counted 161 groups	1833	I counted 33 groups
1828	I counted 225 groups	1834	I counted 51 groups
1829	I counted 199 groups	1835	I counted 173 groups
1830	I counted 190 groups	1836	I counted 272 groups
1831	I counted 149 groups	1837	I counted 333 groups

1826. I observed on 277 days, of which 22 offered no sunspots and many were almost free in August and September. The groups were not very abundant, in March a spot of outstanding size was visible. I saw bright flecks on the 7th and 8th of July and the 3rd and 4th of August.

1827. Observation days, 273. The sun was without spots only

on the 21st and 22nd of January. The groups were rather abundant, irregular seed-spots appeared often. I noted bright flecks in April, May, June, July, August, September and October, often following one another.

1828. Observation days, 282. No day without sunspots. The groups were usually very abundant and their spots appeared very rapidly. In May and September a spot was visible to the unaided eye. Bright flecks were common in June, July, August; scarce in April, May and September.

1829. Observation days, 244. No day without spots. The groups were somewhat scarcer by the end of the year, and diminished in abundance of their spots. In April appeared a notably large seed-spot. Bright flecks were scarce in June and July.

1830. Observation days, 217. The sun was unspotted only on January 24th. The groups often contained irregular seed-spots. Bright flecks appeared only on July 6th, very slightly.

1831. Observation days, 239. The sun appeared only on May 12th, July 2nd, and December 11th without spots. The groups were not very abundant and became constantly scarcer, yet they seemed least in April. Many times there would be only one very regular seed-spot of medium size visible, which had few secondary spots in its train. In June and July appeared broad zones in which the spots arose through strong clouds of light, large grains and distinct pores so conspicuous that they were visible as two belts. Bright flecks were very abundant in July and August; in April, May and September scarce and alone.

1832. Observation days, 270, of which 49 days unspotted; the most of these were in July, August and September. The groups very poor; little spots dissolved very rapidly. No bright flecks.

1833. Observation days, 267. The 139 days when the sun showed no spots fell particularly in June, July, August, October and November. The spots were single and small, often only points, which sometimes dissappeared in a few hours; in October a seed-spot was noticeable for its size and beauty. No bright flecks.

1834. Observation days, 273; 120 days without sunspots, which fell particularly in January, April, May, June, July and August;

in December the spot picture increased considerably. No bright flecks.

1835. Observation days, 244. The 18 days without sunspots were mostly in January. The groups were many times composed of seed-spots with few grains and points. No bright flecks.

1836. Observation days, 200; on no day was the sun unspotted. The groups increased from March on very rapidly, yet the most numerous and abundant appeared only in one hemisphere of the sun. Most noteworthy was the sudden appearance of important seed-spots, and their changeableness. No bright flecks.

1837. Observation days, 168. The sun was never without spots, these increased constantly in the one hemisphere until it was seeded over with them, while more groups united through constantly appearing intermediate spots; their appearance and their changeableness was as sudden and as great as in former years; there appeared, however, more irregular seed-spots and such unusually great stretches of grains that after a chance counting and estimation these often added a thousand spots and points. Bright flecks I saw fairly plentiful only in August; in September scarcer and only one in October.

Heinrich Schwabe.

Dessau, February, 1838.

THE OVERTHROW OF THE MECHANISTIC THEORY*

By J. C. Smuts

THE general trend of the recent advances in physics has thus been towards the recognition of the fundamental organic character of the material world. Physics and biology are beginning to look not so utterly unlike each other. Hitherto the great gulf in nature has lain between the material and the vital, between inorganic matter and life. The gulf is now in process of being bridged. The new physics, in dissolving the material world of common sense and discovering the finer structure of physical nature, has at the same time disclosed certain fundamental features which it has in common with the organic world. Stuff-like entities have disappeared and have been replaced by space-time configurations, whose very nature depends on their principle of organization. And this principle, which I have ventured to call holism, appears to be at bottom identical with that which pervades the organic structures of the world of life. The quantum and space-time have brought physics closer to biology. As I have pointed out, the quantum anticipates some of the fundamental characters of life, while space-time forms the physical basis for organic evolution. Physics and biology are thus recognized as respectively simpler and more advanced forms of the same fundamental pattern in world-structure.

The older mechanistic conception of nature, the picture of nature as consisting of fixed material particles, mechanically interacting with each other—already rudely shaken by the relativity theory—is now being modified by the quantum physics. The attack on mechanism, thus coming from physical science itself, is therefore all the more deadly. Even in physics, organization is becoming more important than the somewhat nebulous entities which enter into matter. Interaction is more and more recognized to be not

*A portion of the Presidential address to the British Association for the Advancement of Science, London, September 23, 1931, by the Right Honourable J. C. Smuts

so much mechanical as organic or holistic, the whole in some respects dominating not only the functioning but the very existence of the entities forming it. The emergence of this organic view of nature from the domain of physics itself is thus a matter of first-rate importance, and must have very far-reaching repercussions for our eventual world-view.

The nature of the organic whole is, however, much more clearly recognized in its proper sphere of biology, and especially in the rapidly advancing science of physiology. Here, too, the correct view has been much obscured by the invasion of mechanistic ideas from the physics of the nineteenth century. A crude materialism all but swamped biology for more than a generation. At the Belfast session of this association in 1874 a famous predecessor of mine in this chair gave unrestained expression to this materialistic creed. All that is passing, if not already past. It must be admitted that up to a point mechanism has been useful as a first approximation and fruitful as a convention for research purposes. But if even in physics it has lost its savour, *a fortiori* has it become out of place in biology. The partial truth of mechanism is always subtended by the deeper truth of organicity or holism. So far from biology being forced into a physical mould, the position will in future be reversed. Physics will look to biology and even to psychology for hints, clues and suggestions. In biology and psychology it will see principles at work in their full maturity which can only be faintly and fitfully recognized in physics. In this way the exchanges of physics, biology and psychology will become fruitful for the science of the future, and lay the basis for a new scientific monism.

A living individual is a physiological whole, in which the parts or organs are but differentiations of this whole for purposes of greater efficiency, and remain in organic continuity throughout. They are parts *of* the individual, and not independent or self-contained units which *compose* the individual. It is only this conception of the individual as a dynamic organic whole which will make intelligible the extraordinary unity which characterizes the multiplicity of functions in an organism, the mobile, ever-changing balance and interdependence of the numerous regulatory processes in it,

as well as the operation of all the mechanisms by which organic evolution is brought about. This conception applies not only to individuals, but also to organic societies, such as a beehive or an ants' nest, and even to social organizations on the human level.

As the concept of space-time destroys the purely spatial character of things, so the concept of the organic whole must also be extended beyond the spatial limits of the organism so as to include its interaction with its environment. The stimuli and responses which render them mutually interdependent constitute them one whole which thus transcends purely spatial aspects. It is this overflow of organic wholes byond their apparent spatial limits which binds all nature together and prevents it from being a mere assemblage of separate interacting units.

It is time, however, that we pass on to the world of mind. From matter, as now transformed by space-time and the quantum, we pass step by step through organic nature to conscious mind. Gone is the time when Descartes could divide the world into only two substances: extended substance or matter, and thinking substance or mind. There is a whole world of gradations between these two limits. On Descartes' false dichotomy the separate provinces of modern science and philosophy were demarcated. But it is as dead as the epicycles of Ptolemy, and ultimately the Cartesian frontiers between physics and philosophy must largely disappear, and philosophy once more become metaphysic in the original sense. In the meantime, under its harmful influence, the paths of matter and mind, of science and philosophy, were made to diverge farther and farther, so that only the revolution now taking place in thought could bring them together again. I believe, however, their reunion is coming fast. We have seen matter and life indefinitely approaching each other in the ultimate constituents of the world. We have seen that matter is fundamentally a configuration or organization of space-time; and we have seen that life is a principle of organization whereby the space-time patterns are arranged into organic unities. The next step is to show that mind is an even more potent embodiment of the organizing whole-making principle, and that this embodiment has found expression in a rising series, which begins practically on the lowest levels of life, and rises ultimately to the

conscious mind which alone Descartes had in view in his classification. I have no time to follow up the matter here beyond making a few remarks.

Mind is admittedly an active, conative, organizing principle. It is forever busy constructing new patterns of things, thoughts or principles out of the material of its experience. Mind, even more than life, is a principle of whole-making. It differentiates, discriminates and selects from its vague experience, and fashions and correlates the resulting features into more or less stable, enduring wholes. Beginning as mere blind tropisms, reflexes and conditioned reflexes, mind in organic nature has advanced step by step in its creative march until in man it has become nature's supreme organ of understanding, endeavor and control—not merely a subjective human organ, but nature's own power of self-illumination and self-mastery—"The eye with which the universe beholds itself and knows itself divine."

The free creativeness of mind is possible because, as we have seen, the world ultimately consists, not of material stuff, but of patterns, of organization, the evolution of which involves no absolute creation of an alien world of material from nothing. The purely structural character of reality thus helps to render possible and intelligible the free creativeness of life and mind, and accounts for the unlimited wealth of fresh patterns which mind freely creates on the basis of the existing physical patterns.

The highest reach of this creative process is seen in the realm of values, which is the product of the human mind. Great as is the physical universe which confronts us as a given fact, no less great is our reading and evaluation of it in the world of values, as seen in language, literature, culture, civilization, society and the state, law, architecture, art, science, morals and religion. Without this revelation of inner meaning and significance the external physical universe would be but an immense empty shell or crumpled surface. The brute fact here receives its meaning, and a new world arises which gives to nature whatever significance it has. As against the physical configurations of nature we see here the ideal patterns or wholes freely created by the human spirit as a home and an environment for itself.

REVIEW OF PUBLICATIONS

Die elliptischen Funktionen von Jacobi, by Milne-Thomson. Pages xiv, 70, 5½×8 in. Price 10½ marks. Berlin: Julius Springer. 1931.

It has long been known that the $\int \sqrt{F}dx$ or $\int dx/\sqrt{F}$, where F is a cubic or quartic in x, constitutes a particular class of functions which cannot be expressed in algebraic or transcendental forms. Any expression of the form $\int f(x\sqrt{F})dx$, where f denotes any rational function, can be reduced to one of three elementary forms, namely

$$\int \frac{d\phi}{(1-k^2\sin^2\phi)^{\frac{1}{2}}}, \quad \int (1-k^2\sin^2\phi)^{\frac{1}{2}}d\phi, \quad \int \frac{d\phi}{(1+n\sin^2\phi)(1-k^2\sin^2\phi)^{\frac{1}{2}}}$$

k and n are constants. If we let $u=\int d\phi/(1-k^2\sin^2\phi)^{\frac{1}{2}}$, we may regard ϕ as a function of u and k and Jacobi's functions are defined by the relations

$$\mathrm{sn}(u,k)=\sin\phi,\ \mathrm{cn}(u,k)=\cos\phi,\ \mathrm{dn}(u,k)=+\sqrt{1-k^2\sin^2\phi}.$$

The evaluation of these integrals is a problem which occurs frequently in the geometry of the ellipse, in differential equations, and in physics under potential, elasticity, Euler's equations, etc. The present volume is a handy compilation of five-figure tables, giving the values of $\mathrm{sn}(u,k)$, $\mathrm{cn}(u,k)$, $\mathrm{dn}(u,k)$ with k^2 called m, and u as arguments. Linear interpolation is all that is required to obtain the values of the functions correct to five places for any value of u and m. There is a useful page of transformation formulae and in addition a table of integrals which can be reduced to depend on the tables. The three functions are placed in separate tables. This has the advantage of making the pages small but entails more turning of pages when the values of all three functions are required for the same values of u and m. This is not serious in a book containing 70 pages only. The printing is clear and the binding good.

R. K. Y.

Atlas Céleste, par E. Delporte. Introduction and 26 charts and 26 tables, $8\frac{1}{2}\times11$ in., with index and key map. Cambridge University Press, 1930.

This is issued as a publication of the International Astronomical Union, in pursuance of the work of delimitation of the boundaries of the constellations, carried through under the auspices of Commission No. 3 and approved by the Union at the Leiden meeting of 1928. It may be of interest to readers to recall that Dr. C. A. Chant, Editor of this JOURNAL, is a member of Commission No. 3, and that Dr. R. K. Young, vice-president of the Royal Astronomical Society of Canada, was a member of the sub-committee which had charge of the work referred to.

For the southern sky the constellations had already been delimited scientifically by B. A. Gould in 1877, but for the northern sky it has hitherto been impossible to make a precise statement of their boundaries, since their delimitation depended merely on the adoption of curves laid down on certain accepted charts; these curves were in many cases not susceptible of mathematical definition, and the boundaries were not authoritatively defined in any other way. Indeed, point is given to the unsatisfactory state of affairs by the fact that a certain number of individual stars have been allocated to different constellations by different authorities, and so appear under different names in different catalogues. The completion of this work and the appearance of the present *Atlas* is therefore of very considerable interest.

The revised boundaries of the constellations consist entirely of arcs of hour-circles and of parallels of declination defined according to the equinox of 1875. In adopting these boundaries the principle was laid down and followed that all variable stars which had been discovered and named up to the end of June, 1929, should be retained in the constellations to which they appertained at the time of discovery, and that, so far as compatible with the above principle, all naked-eye stars should also remain in their original constellations.

Apart from the two polar regions, to each of which a chart is devoted, the sky is divided into four zones of declination, and each zone into six areas, each represented by a chart. On the charts, which are given a generous overlap, are shown all stars to 6.5 magni-

tude, as well as the names and adopted boundaries of the constellations and the usual system of right ascension and declination co-ordinates. On the page facing each chart is a table giving the name, magnitude, spectral type, co-ordinates for 1875, and co-ordinates for 1925, of (1) all stars to magnitude 4.5, (2) variable stars, (3) double stars, (4) nebulae and clusters; each of these groups is arranged in order of right ascension.

The *Atlas*, which forms a companion volume and supplement to "Délimitation Scientifique des Constellations," by the same author, will be in frequent demand for reference by astronomers, and the author is to be congratulated on having successfully carried through a long-needed and important piece of work.

R. M. S.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Another Case of Ball Lightning?

The Toronto newspapers of September 11 reported in a prominent way a violent lightning storm in London, Ont., on the previous day in which the rare "ball" phenomenon was observed. The present writer asked Professor H. R. Kingston to secure statements from eye-witnesses. His reply, dated September 30, is as follows:—

I have interviewed several people regarding the lightning here on the afternoon of Thursday, September 10, and find that none of them, with one possible exception, saw any "ball" phenomenon whatever. That exception is the case of a young lad who said the flash came in the bathroom window like a "ball tapering down towards one end" and disappeared down the wash-basin. He said at its largest part it was about three *feet* across. But he added, "I really cannot tell much about it for it was all in a flash with a terrific crash." As a matter of fact the lightning struck about a block and a half from this house.

A man standing in the front door of a garage got a scare and said his head felt for two or three minutes as though it were blown up with air. He stated that another man standing nearby in the doorway said his forearm was numb for a couple of minutes or so. The former said there appeared to be sparks in the garage, especially around some wires and a metal repair tool. He said also that the sparks seemed to go out the back door. But there was no "ball" appearance. There was no odor.

About fifty yards behind the garage a horse and delivery wagon were standing at the end of a little blind street. The newspaper stated that the horse was stunned and the wagon turned over; but a lady who was sitting at a window a few feet from the horse and saw what happened said the lightning flash and the terrific crash of thunder frightened the animal, which turned around and started to run away, but in doing so it overturned the wagon, got entangled with harness and fell down. The driver got the horse up in a minute or two and it did not seem to be hurt or even stunned by the lightning. A tree about a hundred feet from where the horse

was standing was struck, some bark and twigs were torn off, and also a telephone wire entering a house a couple of feet from the tree was burned off.

In view of the above I have not thought it worth while to put down verbatim the reports of the folks to whom I talked. However, I enclose a note that was sent me in reply to a request in the press for information about the occurrence.

Letter from Alex. G. Robb, a medical student:—

On Thursday, September 10, 1931, I was proceeding east along Dundas Street East, London, Ontario, when at approximately 12.55 p.m. I observed a queer lightning formation accompanied by a very severe peal of thunder.

At the time of observation the sky was heavily overcast with a large dark cloud which had come rapidly from the west and extended well north and south. It was not raining at the time and no other atmospherics had been observed, although previously there had been very distant peals of thunder.

The lightning appeared to come from the most easterly edge of the large dark cloud and seemed to drop perpendicularly with the characteristic zig-zagging of lightning, but not with the usual striking rapidity. It was very bright with a slight bluish color.

It appeared to me to come from a point directly above the southerly side of the street and at an angle of about 25° from the point where I was at the time, which was about 600 feet from the point where the newspaper reported the strike to have taken place.

The lightning was accompanied simultaneously by a very loud peal of thunder which gave me the indication that the lightning had been very close. A curious occurrence was the apparent momentary ceasing of all sounds; especially noticeable was the stillness of the air. Whether this was due to partial deafness created by the thunder or whether it was an accompanying phenomenon I am not prepared to say, but I am inclined to believe it was part of the phenomenon.

Immediately following the occurrence rain began to fall with ever-increasing rapidity, but after about ten minutes it ceased. Only the one atmospheric disturbance was noticed.

THE ORBIT AND MASS OF PLUTO

In Lick Observatory *Bulletin* No. 437, Ernest Clare Bower gives an exhaustive discussion of the orbit and the mass of Pluto. Having deduced new elements he computes an ephemeris for the planet from August 11, 1931, to June 6, 1932. The problem of the mass is attacked in three ways: (1) by its action on Jupiter, Saturn, Uranus, or Neptune; (2) by observations of apparent magnitude with assumed albedo and density; and (3) by observations of apparent diameter with assumed density. The conclusion is that

Pluto's mass cannot be satisfactorily determined gravitationally at present. From observations of magnitude made to date and most favourable assumptions of albedo and density, the upper limit for the mass is 0.7 of the earth's mass. From present observations of apparent diameter and most favourable assumption of density, the upper limit for the mass is 0.3 earth. Until a disc is actually seen, however, the most probable value of Pluto's mass may be taken to be about 0.1 earth, which is very nearly that of Mars.

Fall of an Iron Meteorite on September 7

Science Service supplies information regarding the latest meteoric fall:—

The meteorite fragment that crashed through a garage roof in Hagerstown, Maryland, on the night of September 7 is the world's newest example of a very old class of objects, regarded in antiquity with religious awe and even made the centres of idolatrous worship. The "sacred black stone from heaven" preserved in the Kaaba, or central shrine of the Moslem world at Mecca, is an iron meteorite. Before Mohammed prohibited idolatry among his people, it was the object of actual worship in the primitive, pre-Mohammedan religion of Arabia.

Iron meteorites like the Hagerstown specimen are not as common as stone ones, in the total fall from the skies, but there are more of them in museums, due to the greater likelihood of a stone meteorite's being overlooked as it lies in the open. Nobody knows why some meteorites should consist of pure, or nearly pure, iron, though one theory that is fairly widely accepted holds that they are fragments of the dense inner core of a long-since-destroyed minor planet, drifting through space for ages until they come within the earth's gravitational field. Their light is engendered by friction against the atmosphere as they plunge to the ground.

Meteorites may have been the source of the first iron used in tools by mankind. The little iron used by American Indians in pre-Columbian times was all meteoric. Furthermore, the earliest Mesopotamian references to iron have been translated as meaning "stone from heaven," which may be a hint of meteoric origin of at least the first iron known to the inhabitants of Babylonia and Sumeria.

Copernicus : Facts of His Life

In a recent number of *Science*, the editor of the Polish journal *Nauka Polska*, in writing to correct a misstatement, gives the following brief outline of the life of Copernicus:—

Nicholas Kopernik, called after the Latin manner "Copernicus," was not a German but a Pole. He was born in 1473 in Torun, a town situated in Polish Pomerania, taken in 1793, after the second partition of Poland, by Prussia, recovered by Poland in 1920 by virtue of the Treaty of Versailles. For many

years this borderland of Poland was the scene of many combats between Polish subjects and the Teutonic order of knights known as the Order of the Cross. Both the father and mother of the astronomer were natives of Upper Silesia, an ancient province of the Polish kingdom. The name of the family is purely Slavonic, being derived from the name of a church village "Kopernik," where it had its origin. The father of Kopernik before settling in Torun was living in Cracow, then the capital of Poland.

Kopernik, or Copernicus, was educated in Poland, at first in a school in Wloclawek, a town on the Vistula, later in the University of Jagiellon, in Cracow. From 1491 to 1495 he studied there theology, mathematics and astronomy. He studied afterwards in Italy, as did many Polish scholars in the fifteenth and sixteenth centuries, ecclesiastical law in Bologna and Rome, 1496-1501, and medical science in Padua and Ferrara, 1501-1504, but he did not study in Vienna. In the year 1501 he taught mathematics in the Roman Catholic University "Sapienza" in Rome.

After having returned to Poland in 1504, Kopernik was charged with a high ecclesiastical post as a canon of the Roman Catholic church in Frauenberg in the province of Varmia on the western border of Poland. He did not leave this post until his death in 1543. In Frauenberg he wrote his famous book, "De revolutionibus orbium caelestium," published, however, in Nuremberg, through the interest of his admirer and pupil, George Rhetic, professor in the University of Wittenberg.

In his political and social activity the great astronomer gave evidences of his patriotism. He was known as the author of a plan to amend the money circulating in the Polish western provinces. He also in the period of the Polish combats with the Knights of the Teutonic Order commanded in 1520 the defence of the fortress Olsztyn in the province of Varmia.

The English spelling of the name of the birthplace of Copernicus is Thorn. A good account of Copernicus is given in Berry's "History of Astronomy."

C. A. C.

MEETINGS OF THE SOCIETY

At Victoria

August 27, 1931.—(Extract from Minutes)—Dr. C. S. Beals in the chair.

Mr. W. F. Holdridge, of the Meteorological Observatory, was elected to membership.

Mr. R. M. Petrie, M.A., of Detroit University, formerly of Victoria, delivered a lecture on "Astronomical Instruments." Mr. Petrie told the story of the earliest attempts at constructing a telescope and traced the history of its development to modern times. The lecture was illustrated by many slides showing telescopes—ancient and modern.

After the meeting, the night being suitable for viewing the moon and Saturn, the president addressed a large number of members outside, where a four-inch telescope was used for observation.

September 29, 1931.—Dr. J. A. Pearce, in the chair. Lieut.-Comdr. H. R. Tingley, of the Royal Canadian Navy, was elected to membership.

The subject for discussion for the evening was Finding the Distances of the Stars. The various methods were explained as follows:

(a) Trigonometrical method, F. C. Green, Surveyor-General of British Columbia.

(b) Method of Parallactic Motions, James Duff, M.A., a former president of the Victoria Centre.

(c) Cepheid Variable Method, Philip H. Hughes, the Secretary of the Victoria Centre.

(d) Spectroscopic Method, Galactic Rotation Method, and Inter-Stellar Calcium Method, Dr. Frank Hogg, of the staff of the Dominion Astrophysical Observatory.

As the conclusion, Dr. J. S. Plaskett congratulated the speakers and made instructive comments on the presentation of the various methods.

P. H. Hughes,
Secretary.

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